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This Report is Informal and the Conclusions are only Tentative

SUFFIELD FIELD REPORT NO. 76
(14 June 1944)

Casualty Producing Power of Unthickened Mustard Gas Sprayed from Low Altitudes under Temperate Weather Conditions

REFERENCE

Field Experiment No. 229 carried out 25 May 44.
U.S. Project Co-ordination Board Meeting held at Edgewood 27 April 1944.

INTRODUCTION

1. A series of investigations carried out in the U.S. has indicated that unthickened HS Levinstein, when sprayed from A/C flying at low altitudes and high speeds will not shatter so excessively as to preclude its use against troops wearing all types of battle - dress. (TIMR #821).

2. A series of trials, the first of which is reported here, has been planned by Suffield at the request of the U.S. Project Co-ordination Board for the purpose of investigating under temperate conditions the casualty producing power of unthickened mustard gas sprayed at the contamination densities and drop sizes likely to be encountered in low spraying operations.

3. The trials to be carried out at Suffield are intended to be only of a preliminary nature. From the data obtained here under temperate conditions the U.S. C.W.S. hope to be in a position to assess the casualty producing power of spray when released from multiple fast-flying A/C at low altitudes. It is intended that information along similar lines will eventually be compiled for tropical conditions.

MATERIAL

4. (a) One M 10 Smoke Tank charged 326 lbs. HS Levinstein dyed 0.5% Dupont Oil Red.

(b) The tank was fitted with a No. 2 detonator at the air inlet and a No. 3 detonator at the discharge outlet.

(c) The viscosity (C.V.) of the charging at 25°C was 5.6 centipoises before dyeing and was 15 centipoises after dyeing.

(d) The specific gravity of the charging was 1.34.

(e) The temperature of the charging at take-off was 13°C.

PROCEDURE

Layout

5. A diagram of the layout is given in Appendix I.

Observers

6. Twenty observers were disposed in lines of five each, 60 yards, 80 yards, 100 yards, and 120 yards downwind of the upwind edge of the layout as indicated on the diagram in Appendix I. The interval between observers on each line was 100 yards.

PROCEDURE (cont.)

7. During the spraying, the observers stood facing downwind. They were dressed as follows:

Battle - dress , non-impregnated.
Underwear, long-limbed, winter weight, non-impregnated.
Cotton shirts.
Anklets, socks and boots.
Respirators at the "Gas" position.

(Note: In Canada it is customary to wear long-limbed underwear from late fall to early spring.)

Impermeable clothing (coat and trousers) were worn over the battle-dress, an impermeable hood over the head and rubber gloves on the hands.

8. Windows, 4 in. x 4 in. were cut in the impermeable clothing at the following positions:

(a) At the back of each shoulder (where the clothing is normally in close contact with the skin).

(b) Over each buttock (where clothing is in close contact with the skin and is pressed against the skin in sitting down).

(c) Over each calf (where the clothing is usually loose over the skin).

9. The edges of the windows were sewn down to the battle dress so that no liquid agent could flow down between the outer impermeable clothing and the battle dress.

10. After the spraying the observers moved off the contaminated area and the impermeable clothing was removed. The remainder of the clothing was worn for four hours after the spraying. During this time ten of the men took part in outdoor station fatigues, (digging trenches, raking, etc.). The remaining ten men lay or sat about in a warmed (75°F) room.

Assessment of Ground Contamination

11. Eleven rows of filter paper assemblies, 100 yards between rows, were laid out parallel to the wind direction. Each row was 120 yards long and consisted of filter paper assemblies at 5 yard intervals. At each observer position three additional papers and four large jump cards were placed in proximity to the observer as shown in Appendix I.

Vapour Sampling

12. Two lines of 11 injectors and bubblers (covered with A/G capes) were set up in the downwind section of the layout at 100 yard intervals as shown in Appendix I. A few minutes after the spray the A/G capes were removed and the injectors were turned on. Fifteen minute samples were taken during the first hour and subsequently at the end of the second, third, and fourth hours.

Analysis of the Spray

13. Samples of the sprayed mustard gas were collected in chloroform in pie plates one of which was placed at each observer position, and 10 yards upwind of each observer position. The amount of dye in each plate was determined colorimetrically. The amount of mustard gas on each plate was estimated by the bromine titration method.

14. A sample taken from the spray tank before spraying was treated in the same way.

Functioning of the M 10 Tank

/A20J

15. The M 10 Tank was functioned from the starboard wing stowage of a Boston IV A/C.

16. The A/C flew at a height of 55 ft. at true air speed of 215 mi/hr. The track was indicated by a line of markers and was such that the upwind edge of the contamination fell just inside the upwind edge of the layout.

RESULTS

Meteorological Conditions

17. Time 1250 M.D.T.
Wind Velocity at time of spraying : 12.5 mi/hr.

Sampling Periods

	First Period	Second Period	Third Period	Fourth Period
	1300-1315	1515-1530	1600-1615	1645-1700
Wind velocity at 2 meters (mi/hr.):	15.	11.	18.	14.
Measured R:	1.12	1.11	1.13	1.12
Normal:	1.12	1.11	1.12	1.11
Gustiness: lateral:	.52	.64	.60	.70
vertical:	.29	.31	.33	.32
Air Temperature °C (°F):	19.4(67.0)	23.1(73.6)	18.0(64.0)	22.7(72.9)
Surface Temperature °C (°F):	26.1(79.0)	30.0(85.0)	20.0(68.0)	27.0(80.0)
Relative Humidity:	34%	30%	45%	29%
Temperature Gradient: 39 ft. - 4 ft. °C.	-1.8	-2.2	-1.0	-2.0

Ground Contamination

18. The ground contaminationsfound on the layout filter paper assemblies, and near observer positions are given in Appendix II. Total recovery on the layout was approximately 45%, though it was noted that there was considerable loss off the downwind edge of the layout. These results were obtained by colourimetric estimation of the dye and take no account of evaporation of mustard from the droplets while in flight. It was found impossible to determine the ground contamination density by counting and sizing the stains on the jump cards placed near the observer positions on account of the high density and patchy nature of the contamination found on the cards.

19. The results of chemical and colourimetric analysis of the spray as caught in the chloroform-filled plates are given in Appendix III. These results indicate that of the original H content of the charging (0.71gH/g of original charging) 0.58 g H/gram of the original charging was unevaporated when the spray hit the ground.

Effects on Observers

20. Of the 20 observers exposed to the spray, nine developed vesication on the skin corresponding to the site of the windows in the impermeable clothing they wore. The vesication was most commonly on the shoulders and buttocks. The effects on the calves were considerably slighter and never exceeded erythema.

21. In spite of the fact that only limited portions of the body were unprotected by impermeable clothing, severe vesication developed in four cases necessitating the admission of these men to hospital. In these four cases extensive vesication involved the buttocks and natal cleft, spreading forwards to the perineum. The scrotum was involved by sharp erythema, swelling and vesication; the penis was markedly swollen and erythematous. In addition the areas of vesication on the shoulders extended for an inch or more beyond the site of the windows, and sharp erythema extended in all directions outwards. The severity of these lesions was such that treatment will be necessary in hospital for a least 3 weeks.

22. In the remaining fivecases who developed vesication it was considered that the lesions were such that, if impermeable clothing had not been worn, all these men would have become casualties.

23. A few observers, exposed to contamination densities varying from 1.5 to 2.5 g/sq.m. approximately, developed effects the casualty producing significance of which is difficult to assess. It may be assumed however, that within this range a certain number of delayed casualties (after 5 - 10 days) might be expected.

24. The lesions on the remaining men were trivial and consisted of erythema only. In most cases the reactions on the shoulders and buttocks were of equal intensity, the calves invariably showing milder effects.

25. A summary of the effects on observers together with the relevant data on contamination densities and predominant drop sizes is given in Appendix IV. Descriptions of the lesions produced on this trial are given in Appendix V together with photographs of some of the more interesting ones.

Vapour Sampling

26. The results of vapour sampling are given in Appendix VI. The mean (crosswind) concentration found on the 80 yard line was 3.3 mg/cu.m. 15 min. after the spray had been carried out, and had fallen to 0.88 mg./cu.m. after 4 hours. On the 120 yard line the mean (crosswind) concentration was 1.3 mg./cu.m. at Z plus 15 minutes and had fallen to 0.6 mg./cu.m. after 4 hours.

Discussion of Results

27. Correlating the contamination density with the severity of the lesions, the findings indicate that for drops of 0.4 mm in diameter (0.045 mg) a ground contamination density of 3 g/sq.m. is likely to produce a significant percentage of casualties under the conditions of this trial, i.e. amongst troops wearing three thicknesses of clothing on the upper part of the body.

28. It has also been shown that contamination densities less than 3 g/sq.m. consisting of drops smaller than 0.4 mm. diameter (0.045 mg) are likely to produce effects varying from a mild to a fully developed erythema, with a number of casualties increasing as the contamination density approximates to 3 g/sq.m.

29. The trial did not provide sufficient data to indicate contamination densities which might be casualty producing for drops less than 0.3 mm. in diameter. A second trial is in hand to obtain data on this point.

30. With reference to the spray samples collected in chloroformfilled plates it should be noted that these samples were bottled within fifteen minutes of the spray striking the ground, by which time the chloroform solution had cooled to approximately 0°C. Controls carried out have indicated that loss of mustard vapour from the solution before bottling was negligible.

31. It should be pointed out that the densities of ground contamination used in analysing the physiological effects of the spray were the means of densities found at four positions 25 yards from each of the observer positions and that the density in some cases varied considerably between sampling points about the observer position. (See Appendix II.) The position of the filter paper assembly showing the highest density of contamination of the four assemblies placed near each observer appears to be randomly distributed with respect to wind direction.

32. In correlating ground contamination densities produced by mustard gas spray with the phyiological effect on human observers exposed in regions of various density it must be borne in mind that the amount of mustard falling upon a man exposed to a spray of fine droplets (less than 0.5 mm. diameter) may be more dependent upon the wind speed under which the exposure takes place, than is the case where the spray consists mainly of drops greater than 1 mm. diameter. The larger horizontal component of velocity involved in the fall of fine droplets may tend to increase the amount of mustard falling upon a man standing in a region of a given ground contamination density, as compared with the amount of mustard falling upon him in a region of equal density but where the spray consists of droplets of greater than 1 mm. diameter. This effect will, however, be offset to a certain extent by the decreasing efficiency with which a man's body collects fine droplets as compared with coarse droplets.

33. The limitations set forth in para's 31 and 32 must therefore be given due consideration before the conclusions set forth below are considered as generally applicable to low sprays with unthickened mustard.

CONCLUSIONS

34. The results of this trial indicate that for drops of 0.4 mm. diameter (0.045 mg.) a ground contamination density of 3 g/sq.m. is likely to produce a significant percentage of casualties among men wearing three thicknesses of clothing on the upper part of the body. (battle-dress, cotton shirts, winter-weight underwear).

35. It has also been shown, that under the conditions of this trial contamination densities less than 3.0 g/sq.m. consisting of drops smaller than 0.4 mm. diameter (0.045 mg.) are likely to produce effects varying from a mild to a fully developed erythema, with a number of casualties increasing as the contamination density approximates to 3 g/sq.m.

36. Unthickened HS Levinstein, when sprayed from an M 10 tank on a Boston IV A/C flying at a height of 55 feet at a speed of 215 mi/hr., has contaminated a rectangle 400 yards crosswind by 100 yds. downwind to a density greater than 1 g/sq.m. when the wind speed at two metres is 13 mi/hr. The drop size produced under these conditions varies between 0.1 mm. &.1mm. diam (0.0007 mg. - 0.7 mg.), the predominant drop size being 0.2 to 0.5 mm. diameter. (0.005 to 0.09 mg.).

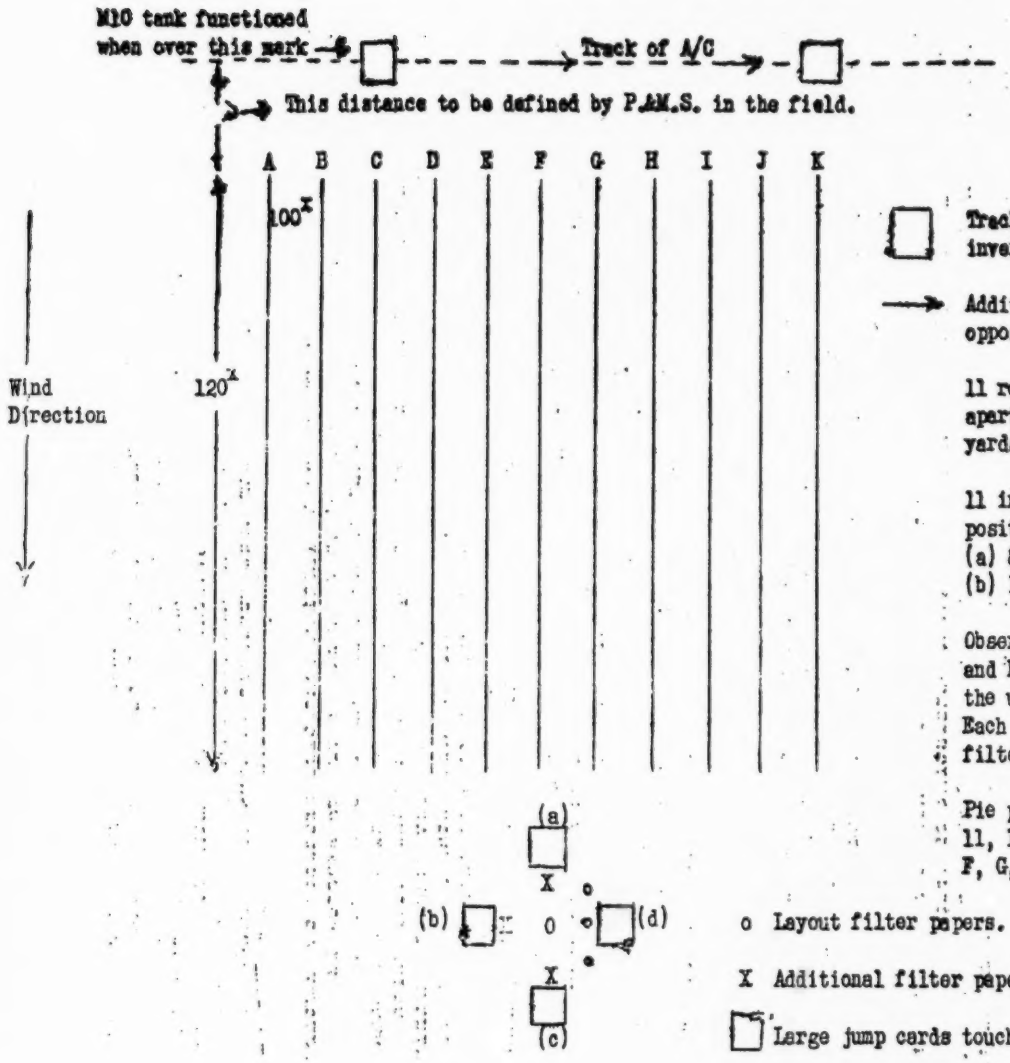
37. Under the conditions of this trial the mean dosage of mustard vapour accumulated along a 1000 yard front, 80 yards downwind of the upwind edge of contamination within the first 4 hours after spraying, was approximately 450 mg. min/cu.m. Similarly the mean dosage accumulated along a 1000 yard front 120 yards downwind of the upwind edge of contamination was approximately 250 mg/cu.m.

38. Under the conditions of this trial, loss of mustard vapour from the spray before it hit the ground was approximately 18% of the mustard content of the charging.

AWB:pkn

(A.W. Birnie) Capt. R.C.E.
P.R.S.
Experimental Station

APPENDIX I



Tracking marks (white jump cards in form of inverted V 4 ft. high) opposite rows C & K.

Additional tracking marks - white jump cards- opposite rows F and I.

11 rows of filter paper assemb es 100 yards apart each row consisting of f ter papers 5 yards apart (25 papers).

11 injectors at 100 yards inte als to be positioned:
(a) 80 yards downwind of upwi edge of layout.
(b) 120 yds. downwind of upwi edge of layout.

Observers will be positioned lines D, E, F, G and H, 60, 80, 100 and 120 y is downwind from the upwind edge of the layou (20 observers) Each observer to have addit nal jump cards and filter papers as shown belc

Pie plates containing chloroform placed at positions 11, 13, 15, 17, 19, 21, 23 and 25 on rows D, E, F, G, and H.

o Layout filter papers.

X Additional filter papers 2½ yards from observer.

Large jump cards touching outer edge of filt r papers.

0 Observer, 2½ yards from layout filter papers
(If observer were at F26 then additional fil papers would t marked F26(a), (b) and (c) and cards F26 (a) (b), (c), and (d).)

APPENDIX II

Ground Contamination (g/sq.m.)

	A	B	C	D	E	F	G	H	J	K	L
1				.067	.21	.0832					
2				.23	.51	.24	.12				
3				1.1	1.5	.66	.60	.0026		.0036	
4				1.7	3.1	1.1	1.1	.10	.017	.0051	
5				2.3	2.9	2.1	.76	.34	.025	.047	
6			.0045	3.3	1.9	3.2	.83	1.2	.0019	.023	
7			.0034	1.8	5.8	1.1	1.9	.018	.053		1.74
8			.0056	3.6	2.3	5.3	1.1	2.3	.035	.043	.013
9			.0026	1.1	3.0	11.	3.4	3.5	.038	.041	.018
10			.010	2.0	1.7	9.9	2.2	.16	.027	1.9	.12
11			.018	1.9	1.5	6.3	2.4	.81	.13	.089	.015
12			.012	1.8	1.3	5.7	2.7	.51	.36	.094	.017
13			.016	3.7 1.4@2.0 0.37	x x @ 4.0 x	7.7 5.7@4.3 8.5	3.1 4.9@1.4 2.0	.30 .57@.53 .73	.39	.056	.013
14			.016	3.0	2.3	6.4	3.5	.37	.75	.034	.0052
15			.029	2.5	2.3	3.6	2.9	.43	.45	.028	.024
16			.047	2.1	3.7	5.6	4.6	.39	.26	.028	.026
17			.011	2.1 1.4@.76 .37	x x @4.0 x	2.9 2.7@4.4 4.1	5.9 4.5@2.6 x	.53 .31@.27 .20	.35	.059	.022
18			.014	2.2	3.9	3.9	3.1	.57	.42	.14	.029
19			.027	1.6	2.3	6.2	1.7	.36	.24	.13	.012
20			.038	1.6	2.9	4.1	.77	.20	.39	.14	.013
21			.094	1.5 .63@1.6 .41	x x @2.4 x	2.6 1.7@7.6 4.0	x 2.6@1.1 .14	.19 .24@.10 .068	.35	.17	.0070
22			.046	1.4	1.3	4.5	1.3	.048	.36	.26	.016
23			.037	1.3	1.5	9.7	1.3	.050	.33	.19	.024
24			.032	1.1	1.2	1.9	1.6	.032	.17	.13	.027
25			.032	1.7 .54@1.9 .92	7.2 .35@.40 .43	9.4 3.5@6.3 2.0	1.7 .89@1.2 .24	.040 .079@.068 .051	.13	.13	.012

Rows A, B, C, D, etc, were 100 yards apart
Lines 1, 2, 3, etc, were 5 yards apart.
Where no contamination is recorded, ground was uncontaminated.

x = missing

@ = observer position

APPENDIX III

Estimation of Mustard Content of Spray when it Reached the Ground

Samples of sprayed HSA were collected in chloroform. The figures quoted are the ratios of the amount of M-10 tank charging present as estimated by dye, and the amount of pure H present, as estimated by titration with 10^{-3} N Bromine.

The original charging showed an H content of 71 ± 3%. The sprayed product, as it reached the ground, showed an average H content of 58 ± 3% in terms of the original charging. Detailed results are given below.

Position	H/ml $CHCl_3$ (By Br) / charging/ml $CHCl_3$ (by dye)	Position	H/ml $CHCl_3$ (By Br) / charging ml $CHCl_3$ (by dye)
D 11	0.60	F 11	0.66
13	0.56	13	0.60
15	0.53	15	0.62
17	0.60	17	0.61
19	0.69	19	0.61
21	0.69	21	-
23	0.73	23	0.39
D 25	0.72	F 25	0.72
Av.	0.64	Av.	0.60
E 11	0.62	G 11	0.74
13	0.61	13	0.64
15	0.59	15	0.48
17	0.48	17	0.70
19	0.47	19	0.60
21	0.45	21	0.65
23	0.47	23	0.61
E 25	0.46	G 25	0.69
Av.	0.52	Av.	0.64
		H 11	0.69
		13	0.48
		15	0.40
		17	0.48
		19	0.47
		21	0.55
		23	0.52
		H 25	0.44
		Av.	0.50

Overall Average Ratio = 0.58

APPENDIX IV

Contamination Density / Drop Size Data

OBSERVER	CONTAMINATION** DENSITY (g/sq.m.)	DROP SIZE (mm.)	(mg.)	TYPE OF LESION PRODUCED	CASUALTY OR NON-CASUALTY
* 13F	6.6	0.55	0.12	V	Casualty
25F	5.3	0.4	0.045	V	"
* 17G	4.3	0.35	0.032	V	"
17E	4.0	0.4	0.045	V	"
* 13E	4.0	0.4	0.045	V	"
21F	4.0	0.45	0.065	V	"
* 17F	3.5	0.45	0.065	V	"
* 13G	2.8	0.45	0.065	V	"
* 21E	2.4	0.35	0.032	E	Non-Casualty
13D	1.9	0.35	0.032	V	Casualty
21G	1.3	0.2	0.006	E -	Non Casualty
25D	1.2	0.2	0.006	E	Non Casualty
* 17D	1.2	0.35	0.032	E +	"
25G	1.0	0.2	0.006	E	"
21D	1.0	0.2	0.006	E	"
13H	0.53	0.2	0.006	E -	"
* 25E	0.49	0.3	0.02	E	"
* 17H	0.33	0.35	0.032	E -	"
* 21H	0.15	0.35	0.032	E -	"
25H	0.06	0.35	0.032	E -	"

* - During the wearing period of 4 hours after the spray, these men were engaged in working in the open, (digging trenches, raking, etc.).

** - The contamination density given here is the mean of the ground contamination densities recorded on filter paper assemblies placed on the ground at four positions 2½ yards from each observer. (See Appendix I).

In the above table the classification of casualty or non-casualty is based on the effects which would be expected if impermeable clothing had not been worn. It may be noted however that observers 25F, 17G, 13E and 13D become casualties requiring admission to hospital in spite of being protected by impermeable clothing except for windows as described in the body of this report.

APPENDIX V

DESCRIPTION OF LESIONS PRODUCED BY LOW SPRAY OF UNTHICKENED MUSTARD GAS

(Note: It should be borne in mind that during the spray the observers, whose lesions are described below, wore impermeable clothing. A window, 4" x 4", was cut out of the impermeable clothing over each shoulder, over each buttock, and over each calf exposing the clothing beneath. The impermeable clothing was sewn down at the edges to the Battle Dress so that no liquid agent could flow down between the outer impermeable clothing and the Battle Dress. The classification of casualty or non-casualty is based on the effects which would be expected if impermeable clothing were not worn.)

* During the wearing period of 4 hours after the spray, these men were engaged in working in the open, (digging trenches, raking etc.). The remaining men lay or sat in a warmed room (75°F.) for 4 hours.

* OBSERVER 13F

Contamination Density 6.6 g/sq.m.; Drop Size 0.55 mm. (0.12 mg.). Twenty-four hours after the spray the left shoulder showed intense vesication and the right shoulder erythema. After 48 hours the right shoulder had developed pinpoint vesication. (See Plate I.)

Casualty.

* OBSERVER 17G

Contamination Density 4.3 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). Twenty-four hours after the spray both shoulders were vesicated. Erythema extended from both vesicated sites downwards between the shoulderblades to the waist. The buttocks showed intense erythema which at 48 hours had proceeded to vesication at the upper part of the natal cleft. The calves never developed more / a mild erythema. / than On the 4th day after the spray the scrotum showed intense erythema with areas of excoriation. The penis was slightly swollen. (See Plate II).

Casualty.

OBSERVER 25F

Contamination Density 5.3 g/sq.m.; Drop Size 0.4 mm. (0.045 mg.). Twenty-four hours after the spray both shoulders showed areas of intense vesication. Erythema extended from the nape of the neck to the waist. The buttocks were involved by vesication which extended far beyond the areas exposed by the windows. Vesication involved the entire natal cleft. By the 2nd day the vesication had spread forwards to involve the perineum. The scrotum was intensely inflamed and swollen and numerous small blisters were scattered over it. The penis was swollen with small areas of excoriation due to minute broken blisters. The left leg showed an area of erythema which by 48 hours had proceeded to vesication. On the 4th day after the spray this man was very distressed, the vesication on the buttocks and perineum having continued to develop. Even after application of different types of treatment to the lesions, he complained of incessant pain and irritation, particularly of the scrotum and penis. The temperature reached 102°F. The glands in the groins became swollen and tender and insomnia was marked. On the 5th day the condition had improved and irritation was less marked. By this time the lesions had apparently reached their full maturity. When considering the severity of the lesions produced on this observer, it should be borne in mind that only windows, 4" x 4",

OBSERVER 25 F (cont.)

were cut in his impermeable clothing. If no protection had existed, it may be assumed that the severity of the lesions would have been considerably greater. (See Plates III & IV.)

Casualty.

OBSERVER 17E

Contamination Density 4.0 g/sq.m.; Drop Size 0.4 mm. (0.045 mg.). Twenty-four hours after the spray erythema was present on both shoulders, a mild erythema on both buttocks and no reaction had developed on the calves. On the 2nd day after the spray there were areas of pinpoint vesication on both shoulders. On the following day these areas of pinpoint vesication on the shoulders had progressed to true vesication. Neither the buttocks nor the legs showed significant lesions at any time.

Casualty.

* OBSERVER 13E

Contamination Density 4.0 g/sq.m.; Drop Size 0.4 mm. (0.045 mg.). Twenty-four hours after the spray both shoulders showed vesicated areas which continued to increase in size and intensity during the second day. Severe vesication developed on the buttocks chiefly over the site of the windows and extending to the upper part of the natal cleft. These lesions also continued to increase in severity until the second or third day after the spray. On the second day mild erythema developed on the penis and scrotum. The calves showed a mild erythema. (See Plates V and VI).

Casualty.

OBSERVER 21F

Contamination Density 4.0 g/sq.m.; Drop Size 0.45 mm. (0.065 mg.). Twenty-four hours after the spray both shoulders showed areas of pinpoint vesication. The buttocks showed diffuse erythema and the calves a slight degree of erythema. By the 48th hour both shoulders were vesicated, the erythema on the buttocks more intense, with vesication on the upper part of the natal cleft.

Casualty.

* OBSERVER 17F

Contamination Density 3.5 g/sq.m.; Drop Size 0.45 mm. (0.065 mg.). Twenty-four hours after the spray, both shoulders were involved by pinpoint vesication and both buttocks and calves by erythema. Forty-eight hours after the spray, vesication appeared on buttocks and in the natal cleft.

Casualty.

* OBSERVER 13G

Contamination Density 2.8 g/sq.m.; Drop Size 0.45 mm. (0.065 mg.). Twenty-four hours after the spray both shoulders showed areas of pinpoint vesication. There was no reaction on buttocks or calves. By the third day the left shoulder was vesicated and the right shoulder showed an intense erythema which did not progress to vesication. No effects appeared on the buttocks or calves.

Casualty.

* OBSERVER 21E

Contamination Density 2.4 g/sq.m.; Drop size 0.35 mm. (0.032 mg.). Twenty-four hours after the spray both shoulders were involved by erythema. The buttocks were erythematous. The calves showed no reaction. Over the succeeding few days these lesions showed no appreciable increase in intensity. Since only six small circumscribed areas of uncovered battle dress were exposed to the spray, it is difficult to say in the case of observers contaminated to densities of this order whether or not the lesions would be of casualty severity if the impermeable clothing had not been worn. Until the question is settled by further observation, these men are classified as non-casualties with the reservation that a number of them may become casualties after an interval of 5 to 10 days or later.

Non-casualty.

OBSERVER 13D

Contamination Density 1.9 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). Twenty-four hours after the spray the left shoulder was vesicated. The right shoulder showed pinpoint vesication. Erythema involved both buttocks and a mild erythema had developed on both calves. Forty-eight hours after the spray the vesication on the shoulders had increased in intensity. Vesication had appeared at the top of the natal cleft. The scrotum and penis were involved by a sharp erythema. Four days after the spray the penis and scrotum were still severely inflamed with small areas of excoriation and exudation on the scrotum.

Casualty.

OBSERVER 25D

Contamination Density 1.2 g/sq.m.; Drop Size 0.2 mm. (0.006 mg.). Twenty-four hours after the spray both shoulders and buttocks showed a mild erythema. Mild erythema also involved the penis and scrotum. Over the succeeding days these lesions did not increase in intensity.

Non-casualty.

OBSERVER 21G

Contamination Density 1.3 g/sq.m.; Drop Size 0.2 mm. (0.006 mg.). Twenty-four hours after the spray a mild erythema had developed on the shoulders. No effects were produced on the buttocks or calves. Over the succeeding days no change in the lesions developed.

Non-casualty.

OBSERVER £5 G

Contamination Density 1.0 g/sq. m.; Drop Size 0.2 mm. (0.006 mg.). Twenty-four hours after the spray a mild erythema had developed on the shoulders. The buttocks were involved by a slightly more intense erythema. No effects were produced on the calves. Over the succeedings days these lesions did not develop any further.

Non-casualty.

OBSERVER 21D

Contamination Density 1.0 g/sq.m.; Drop Size 0.2 mm. (0.006 mg.). The lesions produces on this observer were confined to areas of mild erythema on the shoulders, back and calves.

Non-casualty.

* OBSERVER 17D

Contamination Density 1.2 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). Twenty-four hours after the spray a mild erythema had developed on the shoulders, back and calves. Forty-eight hours after the spray the lesions on the shoulders and back had developed in intensity but did not progress to vesication. Slight erythema accompanied by itching of the scrotum and penis had developed.

Non-casualty.

OBSERVER 13H

Contamination Density 0.53 g/sq.m.; Drop Size 0.2 mm. (0.006 mg.). Beyond a mild degree of erythema on the buttocks this observer developed no effects.

Non-casualty.

* OBSERVER 25E

Contamination Density 0.49 g/sq.m.; Drop Size 0.3 mm. (0.02 mg.). This observer developed a mild erythema on the shoulders, back and calves. The lesions did not increase in intensity.

Non-casualty.

* OBSERVER 17H

Contamination Density 0.33 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). The only effects produced on this observer were two areas of mild erythema on the shoulders.

Non-casualty.

* OBSERVER 21 H

Contamination Density 0.15 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). Beyond a mild erythema on the shoulders this man displayed no effects.

Non-casualty.

OBSERVER 25H

Contamination Density 0.06 g/sq.m.; Drop Size 0.35 mm. (0.032 mg.). A mild erythema developed on both shoulders. No effects were produced on the buttocks or calves.

Non-casualty.

APPENDIX VI

Vapour samples were taken at 100 yd. intervals on lines 80 yards, and 120 yards downwind from the upwind edge of the layout. Samples were taken from Z + 7 to Z + 22 min., Z + 2 hrs. to Z + 2.17, Z + 3.18 Z + 4.hrs. to Z + 4.17. Results were analysed by the bromine titration method, and corrected for bubbler efficiency.

Mean Concentration Over Sampling Period (mg/cu.m.)

80 yd line	Z + 7-Z + 22	Z + 2 hrs.Z + 2.17	Z + 3 hrs.Z + 3.18	Z + 4-4.17
Position 1	1.29	0.25	0.30	1.73
2	0.17	2.04	1.01	0.24
3	0.32	4.24	2.31	0.20
4	8.52	0.21	2.18	0.09
5	1.35	1.36	0.19	0.10
6	8.40	2.79	0.15	1.10
7	2.22	0.30	0.15	—
8	5.70	1.14	0.16	0.71
9	0.20	7.09	0.40	0.34
10	0.63	0.30	0.43	0.30
11	7.34	1.21	0.32	4.85
Average	3.3	1.9	0.69	0.96
120 yd line				
1	2.6	1.74	0.18	0.87
2	0.64	0.47	1.51	0.41
3	0.19	0.20	4.35	0.14
4	.29	0.31	4.09	0.57
5	2.0	1.33	3.35	0.64
6	2.0	3.68	0.26	1.00
7	1.1	0.20	0.55	2.53
8	0.88	0.17	1.00	0.13
9	0.74	2.92	0.50	0.22
10	2.75	0.42	0.26	---
11	0.80	0.35	0.30	0.16
Average	1.27	1.07	1.49	.67

Plate I 6-B-37-790-6
Observer 13F. 24 hours after spraying with unthickened mustard gas. One large vesicle surrounded by an area of intense erythema with pin point vesication has developed under the site of the window on the left shoulder.

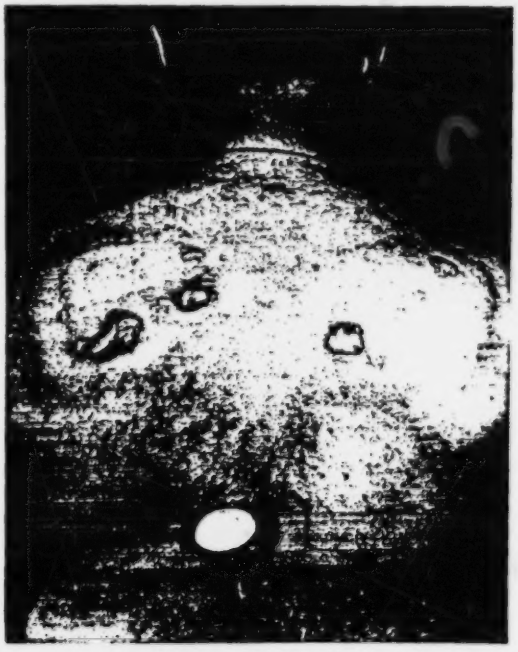


Plate II 6-B-37-790-9
Observer 17G. 24 hours after spraying with unthickened mustard gas. The portions of the skin corresponding to the windows cut in the impervious clothing are occupied by vesication. Erythema spreads outwards beyond these areas, is coalescent in the mid-line, and spreads downwards towards the waist. This observer also sustained vesication on the buttocks and in the natal cleft.

Plate III 6-B-37-790-1

Observer 25F. 24 hours after spraying with unthickened mustard gas. Areas of intense vesication have involved the skin beneath the windows in the impermeable clothing. Erythema has spread in all directions, is coalescent at the middle of the back and has spread downwards towards the waist. (See Plate IV)

Plate IV 6-B-37-790-3

Observer 25F. The same observer as illustrated in Plate III. Both buttocks are involved by intense erythema and vesication spreading far beyond the limits of the skin unprotected by the impermeable clothing. Severe vesication has involved the natal cleft and has spread forwards to the perineum, scrotum and penis. For 4 hours after the spray this observer lay or sat about on his contaminated clothing. Such behaviour frequently accentuates the severity of a lesion due to pressure of contaminated clothing on the underlying skin.

[redacted]

Plate VI 6-B-37-790-4
Observer 13E. The same observer as illustrated in Plate V. Sharp erythema has extended outwards from these lesions, has coalesced at the mid line and extended inwards at the natal cleft. These lesions increased in severity over the succeeding few days.

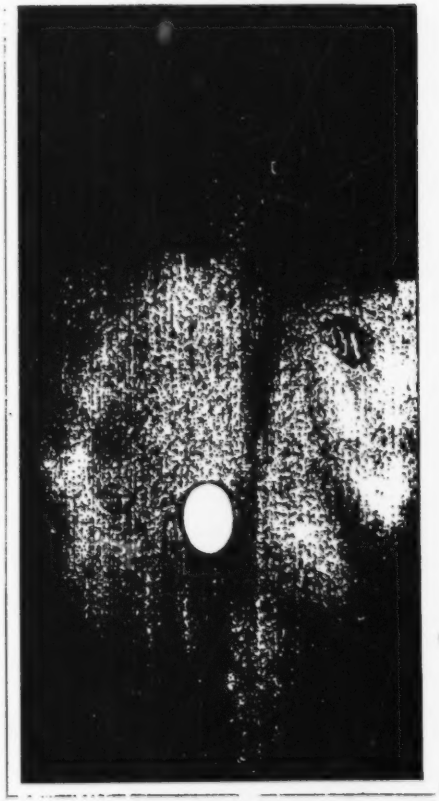


Plate V 6-B-37-790-5
Observer 13E. 24 hours after spraying with unthickened mustard gas. Vesication has developed more severe on the right shoulder, than on the left. (See Plate VI).

~~Transparency~~

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